REMARKS

The substitute specification together with the amended claims and drawings place the present U.S. national phase application in better form for examination on the merits.

Also attached hereto is an Abstract of the Disclosure presented on a separate sheet in conformity with the rules of practice.

Based upon the specification, drawing, and claim amendments to this national phase application, it is believed that the amended specification and amended drawings and claims conform with U.S. formal requirements. Additionally, the amended claims as hereinabove presented conform in substance with the corresponding amended claims that were examined in the international application. And based upon the acceptance by the International Preliminary Examining Authority of the invention as it was claimed in the amended claims that were presented in the international application as meeting each of the novelty, the inventive step, and the industrial applicability criteria set forth in the Patent Cooperation Treaty, the claims as amended above are believed to conform with both U.S. formal and U.S. substantive requirements, and they are therefore believed to be in allowable form. Accordingly, an early Notice of Allowance is in order and is respectfully solicited.

Should the examiner have any question after considering this Preliminary Amendment, he is cordially invited to telephone the undersigned

attorney so that any such question can be quickly resolved in order that the present application can proceed toward allowance.

Respectfully submitted,

October 3, 2004

Alfred J. Mangels
Reg. No. 22,605
4729 Cornell Road
Cincinnati, Ohio 45241
Tel.: (513) 469-0470

Attachments: Attachment A
Attachment B
Abstract of the Disclosure
Annotated drawing sheet showing the changes
Replacement drawing sheet including the changes

ATTACHMENT A

SUBSTITUTE SPECIFICATION
(Including All Changes from the Specification in Published International Application No. PCT/SE03/00386, Publication No. WO 03/087016 A1)

ELECTRICAL HEATING RESISTANCE ELEMENT

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001] The present invention relates to an electrical resistance heating element.

DESCRIPTION OF THE RELATED ART

[0002] Heating elements of the kind described herein are intended for use in heat treatment and sintering processes, in inert and reducing atmospheres, and also oxidizing atmospheres and vacuum conditions, up to extremely high temperatures, such as temperatures as high as 2300 °C, but also at low temperatures, e.g., temperatures of 500 °C.

[0003] Resistance heating elements of the present kind are manufactured by applicants. The resistance heating elements are of a widely varying form and are based on NiCr, FeCrAl, SiC, $MoSi_2$, and alloys of those materials. Those materials are used in a plurality of atmospheres and at different temperatures. Heating elements that are composed mainly of Mo, W, Ta (tantalum), and graphite are used at temperatures around and above 2000 °C. In the case of lower temperatures a molybdenum silicide and aluminum oxide composite material is used.

[0004] The heating elements include one, two, or more legs, as well as two terminals for connection to a source of electric current. The diameter of the terminals is greater than the diameter of the glow zones of the elements, to reduce the amount

of heat generated at the terminals. The elements are in the form of homogenous rods through which electric current flows.

[0005] There is a desire to increase the electrical resistance in the glow zone of the element to obtain the same element temperature at a lower current strength, which would greatly lower the power supply operating costs of the elements.

[0006] The solution in which the element is provided with a smaller outer diameter, and therewith a higher electrical resistance, results in a smaller element radiation surface, which is highly disadvantageous since a larger radiation gives a larger heat yield through radiation heat. Moreover, thin elements result in mechanical strength problems at high temperatures.

[0007] Such desirable attributes are fulfilled by the present invention.

SUMMARY OF THE INVENTION

[0008] Accordingly, the present invention relates to an electrical resistance heating element that includes a glow zone and two power supply terminals. The glow zone of the heating element is tubular, and a connecting piece or union means is provided between respective terminals and respective ends of the glow zone.

BRIEF DESCRIPTION OF THE DRAWING

[0009] The invention will now be described in more detail, partly with reference to an exemplifying embodiment thereof illustrated in the accompanying drawing, in which:

[0010] Figure 1 illustrates a two-leg heating element, and

[0011] Figure 2 illustrates union means.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0012] It will be understood that application of the invention is not limited to two-leg heating elements, but that the invention can also be applied to heating elements that have two or more legs.

[0013] Figure 1 is a longitudinal, partially sectioned view of a two-leg heating element 1.

[0014] The electrical resistance heating element 1 includes a glow zone 2 and two power supply terminals 3, 4.

[0015] According to the invention, the glow zone 2 of the element 1 is tubular. Figure 1 also shows union means 5, 6 between respective terminals 3, 4 and respective ends 7, 8 of the glow zone 2,

[0016] Because the glow zone is tubular and has an outer diameter that corresponds to the outer diameter of a corresponding typical heating element, the radiation surface area will be the same. On the other hand, as a result of the smaller cross-sectional area a lower current strength is required through the glow zone in order to obtain the same element temperature. That lower current strength lowers significantly the costs incurred by the element power supply equipment, while providing the same temperature and heat output.

[0017] The union means 5, 6 will preferably also be tubular, although with a greater wall thickness, which due to the lower electrical resistance of glow zone 2 will

result in a lower union means temperature. The same result applies to the terminals 3, 4.

[0018] In order to avoid sharp temperature gradients, the union means 5, 6 have a larger inner diameter at their ends attached to the glow zone 2.

[0019] According to one preferred embodiment of the invention, the glow zone 2 has essentially the same inner diameter as the largest inner diameter of the union means 5, 6.

[0020] According to another preferred embodiment of the invention, the union means 5, 6 have essentially the same outer diameter as the glow zone 2, while the wall thickness of the union means decreases progressively towards its end facing towards the glow zone, see Fig. 2. Figure 2 is an enlarged view of the circled area in Fig. 1.

[0021] With the intention of adapting the union means to both a welding operation, in which one end of the union means is welded in abutment with the end of the glow zone, and to the operation of the element, it is preferred that the progressively decreasing wall thickness follows a function illustrated in Fig. 2 in which are shown a number of illustrative measurements for various portions of the heating element adjacent to glow zone end 8.

[0022] Thus, it is preferred that the progressively decreasing wall thickness results from a variation of the radius at the inner wall surface 9 within a transition region that extends from a smaller inner diameter within union means 6 to a larger inner diameter at glow zone end 8. The radius of the inner wall surface at any axial position along the transition region complies with the function $r = \frac{ro}{\sqrt{lo}}\sqrt{l}$, where *l*

coincides with a position along the longitudinal axis of the union means, *r* corresponds to the inner radius of the union means, *lo* corresponds to the overall length of the transition region along which the wall thickness decreases, and *ro* corresponds to the largest inner radius of the union means at a point adjacent to glow zone end 8.

[0023] The largest inner radius of the union means is typically 3 - 5 times larger than the smallest inner radius.

[0024] It is also preferred that respective union means 5, 6 and respective terminals 3, 4 together form a one-piece structure.

[0025] The resistance elements are produced in different dimensions, for instance with an outer diameter of 9, 12, and 16 mm. The union means dimensions and the glow zone dimensions will, of course, be adapted to each other, for instance in accordance with the above formula.

[0026] Typical element proportions may be such that in the case of an element with a glow zone that has an outer diameter of about 12 mm, its inner diameter will be about 10 mm. The union means will have an outer diameter of about 12 mm and a smallest inner diameter of about 3 mm, while the progressively decreasing wall thickness of the union means will extend through a distance of about 16 mm.

[0027] The inventive heating element can be produced from all sorts of materials that are produced by applicants, among others, for a number of different applications. Thus, application of the invention is not limited to high temperature elements, but can be applied equally as well for low temperature applications.

[0028] The wall thickness of the glow zone can have dimensions other than those given above, depending upon the application concerned, among other things.

[0029] The transition between the union means and the glow zone can have a different form, while ensuring that sharp temperature gradients, and therewith thermal stresses are avoided.

[0030] The present invention shall not therefore be considered limited to the above described embodiments, since variations can be made within the scope of the accompanying claims.

What is claimed is:

ATTACHMENT B

SUBSTITUTE SPECIFICATION
(Showing All Changes from the Specification in Published International Application No. PCT/SE03/00278, Publication No. WO 03/073792 A1)

A MOLYBDENUM SILICIDE TYPE ELEMENT

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to an electrical resistance element of the molybdenum silicide type.

DESCRIPTION OF THE RELATED ART

Such elements have long been known in different forms with regard to their different alloy contents. Kanthal AB of Sweden are manufacturers of such elements. These types of elements are ~~summarised~~ referred to as molybdenum silicide-type elements, which have long been used to heat ovens and different kinds of surfaces, such as a radiating surface that radiates onto an object, or cooker plates, or other surfaces.

Molybdenum silicide elements are produced in different forms. A typical form is a so-called leg element, which comprises two legs that extend between two electrical conductors or terminals at one of their ~~one~~ ends ~~and that~~ . The legs are joined with an arcuate or curved part at their other ends. The leg elements can consist of one, two, or more legs. Two-legged elements, or multi-leg elements, include one or more curved parts that extend between the conductors. The leg constitutes a glow zone, i.e., that part of the element that glows when supplied with electric current, and therewith delivers heat to an object.

One problem experienced with industrial furnaces, ovens, and the like resides ~~sometimes~~ in the difficulty at times of maintaining a sufficiently uniform temperature distribution in a furnace space, or in achieving sufficiently uniform thermal radiation from a radiating surface. An uneven temperature distribution or uneven radiation will mean that the space or the object to be heated will not be heated uniformly, which can be highly problematic.

A concrete example is when liquid-metal ladles ~~shall~~ are to be pre-heated. Uneven heating of a ladle presents a problem when using resistance elements, as the bottom of the ladle will not be as hot as the inner walls of the ladle.

The known method of attempting to resolve this problem involves the installation of a number of elements or groups of elements that can be controlled individually, so that different elements have delivered power of different high magnitudes.

The present invention solves the problem caused by uneven heating.

SUMMARY OF THE INVENTION

Accordingly, the present invention relates to an electrical resistance element of the molybdenum silicide type that includes two terminals for the supply of electric current ~~and at~~ . At least one ~~leg which~~ connecting member extends between the terminals and ~~which~~ includes a glow zone ~~, wherein the invention is characterised in that the~~ . The glow zone has different diameters along different ~~leg~~ connecting member sections.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in more detail, partly with reference to the embodiments of the invention shown in the accompanying drawings, in which

Figures 1, 2, and 3 show different forms of two-legged heating elements, and

Figure 4 ~~illustrates~~ shows a four-legged heating element.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The respective relative measurements of certain parts of the elements have been shown in the drawings for the sake of clarity. It will be understood, however, that these measurements have been given only by way of example. In the Figures, reference character Lu indicates the length of the terminals and reference character Le indicates the length of the glow zone. ~~References~~ Reference characters Le1, Le2, and Le3 indicate the ~~length~~ lengths of different sections of the glow zone of the element, and reference character "a" indicates a distance.

According to one embodiment, an electric resistance element of the present type includes two electricity supply terminals 1, 2, and two legs 3, 4, ~~5~~ which extend between the terminals and which include a glow zone.

According to the present invention, the glow zone has different diameters along different sections of the ~~leg~~ legs.

This means that the heat developed will differ in magnitude along different sections of the element, due to the disparity in the amperage or current intensity in each applicable cross-sectional area of the element. The invention thus allows an

element to be designed in accordance with the heating requirements that exist along the full ~~extension~~ extent of the element.

An inventive element of the kind illustrated in Figure 1 can be used in the case of the above example concerning a ladle whose bottom is not heated sufficiently in relation to the inner walls of the ladle when using a known element. The inventive element has terminals having a diameter of 24 ~~millimetres~~ millimeters, and two legs 3, 4 whose upper ~~part is~~ parts are12 ~~millimetres~~ millimeters in diameter and ~~a~~ lower ~~part~~ parts which ~~is~~ are 10 ~~millimetres~~ millimeters in diameter. Such an element will become hotter at its narrower, lower, part. This higher temperature will make that part of the object located close to this section of the ladle much hotter.

According to one embodiment of the invention, the element has two [[-]] legs with only one curved part 3a between the terminals 1, 2; see Figure 1.

According to another embodiment of the invention, the element has four legs, see Figure 4, or more, and includes two curved parts 4a, 5a, or more, between the terminals 1, 2.

An element of the present kind may also be formed with only one leg, for example ~~with~~ a straight leg that has a terminal at each end.

Figure 2 illustrates an embodiment in which the glow zones have mutually different diameters along different sections 6, 7, 8 of the legs, where the diameters of respective sections become smaller with increasing ~~distances~~ distance of the respective sections 6, 7, 8 from the terminals 1, 2.

Figure 3 illustrates an embodiment in which the glow zone has mutually different diameters along different sections 9, 10, 11 of the legs 3, 4, where the

~~diameter~~ diameters of the sections ~~varies downwards~~ decrease and ~~upwards~~ increase along the legs. The same design can, of course, be ~~given to~~ utilized in elements that have two or more legs. In the Figure 3 embodiment, the sections 9 and 11 have a diameter of 10 ~~millimetres~~ millimeters and the section 10 has a diameter of 12 ~~millimetres~~ millimeters.

In the case of certain applications, the glow zone will preferably have different diameters along different leg sections, wherein the ~~diameter~~ diameters of respective sections ~~is~~ are smaller the closer the sections are to the terminals. In the Figure 4 embodiment, the sections 12, 13 have a diameter of 8 ~~millimetres~~ millimeters, while the sections 14-17 have a diameter of 9 ~~millimetres~~ millimeters.

Although only ~~flat~~ elements that lie in a single plane are shown in the Figures, it will be understood that ~~the~~ an element may include two or more legs, where one, two, or more legs, or parts thereof, define an angle with a plane in which the terminals lie.

The elements may be designed to heat a volume in a known manner, or to form a radiating surface. Moreover, the elements may be designed, and possibly supported, for mounting vertically, horizontally, or at another angle to the horizontal plane.

The different embodiments illustrated in the drawings are, of course, exemplifying embodiments with regard to shape and diameters. As will be obvious to those skilled in this art, elements can be given generally any shape and form, with mutually different diameters that provide the heating effect desired for a particular application. The present invention is ~~therefor~~ therefore not limited to any particular element design, as long as different sections have different diameters.

The present invention shall not therefore be considered to be restricted to the described and illustrated embodiments, since variations and modifications can be made within the scope of the accompanying claims.

~~Claims~~

What is claimed is:

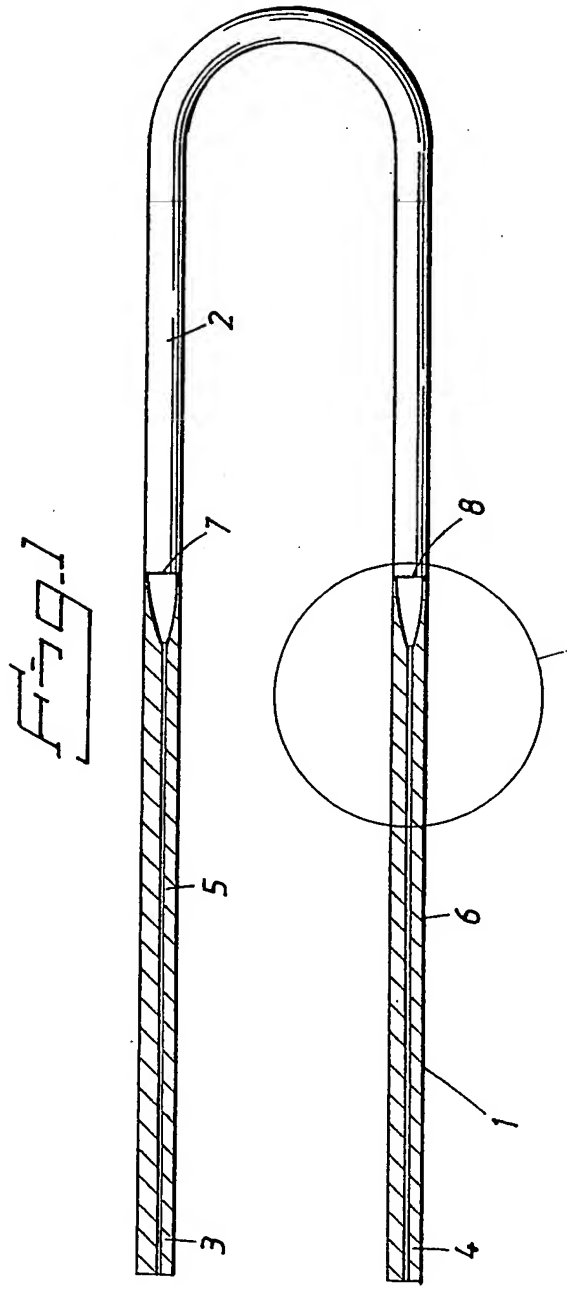

Fig. 1

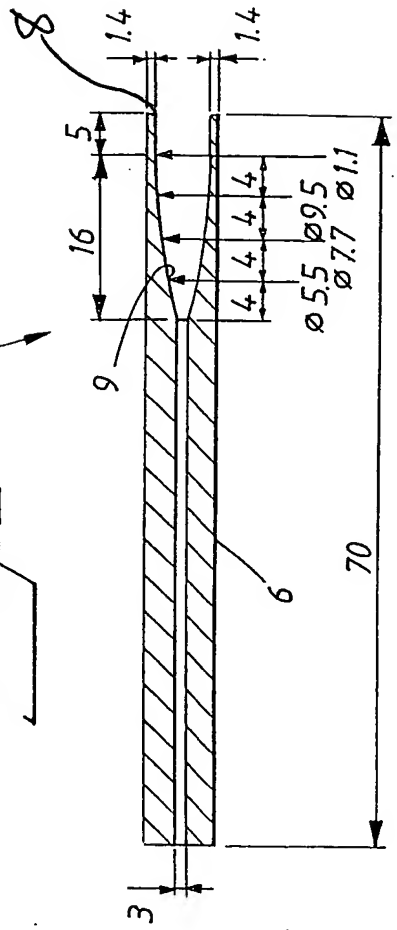

Fig. 2